

Final Technical Report

on

NAG 5-388

AREAL COVERAGE OF STORM PRECIPITATION

Submitted by

Peter S. Eagleson

Edmund K. Turner Professor of Civil Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

August 1, 1985



Final Technical Report on

NAG 5-388

AREAL COVERAGE OF STORM PRECIPITATION

A. Objective

The objective of this research was to derive the probability distributions of the spatial distribution of precipitation from storms of different types in terms of parameters of the commonly observed "point" or station precipitation. This information is essential to accurate soil moisture accounting in lumped water balance calculations for the large grid-square areas of atmospheric general circulation models.

B. Accomplishments

1. Moments of Wetted Rainstorm Area

The occurrence of wetted rainstorm area within a catchment was modeled as a Poisson arrival process in which each storm is composed of stationary, nonoverlapping, independent random cell clusters whose centers are Poisson-distributed in space and whose areas are distributed as though fractals. The two Poisson parameters and hence the first two moments of the wetted fraction are derived in terms of catchment average characteristics of the (observable) station precipitation. The model was used to estimate the spatial properties of tropical air mass thunderstorms on six tropical catchments in the Sudan. This work has been published:

Eagleson, P.S., "The Distribution of Catchment Coverage by Stationary Rainstorms," Water Resources Research, 20(5), 581-590, 1984.

2. Moments of Catchment Storm Area

The portion of a catchment covered by a stationary rainstorm has been modeled by the common area of two overlapping circles. Given that rain occurs within the catchment and conditioned by fixed storm and catchment sizes, the first two moments of the distribution of the common area are derived from purely geometrical considerations. The variance of the wetted fraction is shown to peak when the catchment size is equal to the size of the predominant storm. The conditioning on storm size is removed by assuming a probability distribution based upon the observed fractal behavior of cloud and rainstorm areas.

This work which also received support from NSF under ATM-8114723 has been accepted for publication and will appear shortly.

Eagleson, P.S. and Q. Wang, "The Moments of Catchment Storm Area", Water Resources Research (in press) 1985.

3. Spatial Modeling of Storm Rainfall

The spatial structure of the depth of rainfall from a stationary rainstorm has been investigated using point process techniques. Cells are assumed to be stationary and to be distributed in space either independently according to a Poisson process, or with clustering according to a Neyman-Scott scheme. Total storm rainfall at the center of each cell is a random variable and rainfall is distributed around the center in a way

specified by a spread function that may incorporate random parameters. The mean, variance and covariance structure of the precipitation depth at a point are obtained for different spread functions. The probability of zero rainfall at a point is investigated.

This work benefitted from the support received by the other investigators from institutions in their home countries. The work has been submitted for publication.

Rodriguez-Iturbe, I., D.R. Cox and P. S. Eagleson, "Spatial Modeling of Storm Rainfall", (Submitted to Philosophical Transactions of the Royal Society, London) 1985.

4. Application of Spatial Poisson Models to Air Mass Thunderstorms

Work begun under NAG 5-388 and continuing with NSF support under ATM-8420781 is applying the models of Rodriguez-Iturbe, Cox and Eagleson to summer storm rainfall observed at a network of raingages on the Walnut Gulch experimental catchment of the Agricultural Research Service (ARS).

This work has developed software for reading the ARS data tapes and sorting the time series at 93 stations into about 500 storms. These station storm depths are used with an interpolating program to define the random field of storm depth on a fine meshed grid; statistical descriptors of the depth field are calculated such as mean, variance, skew, correlation function, variance function, and depth-area.

A numerical simulation of the random field of storm depth has been developed based upon the conceptual models of Rodriguez-Iturbe, Cox and Eagleson. This has proved very useful in understanding the sampling problem introduced by the finite Walnut Gulch catchment.

The observational sample has been split and one-half is being used to evaluate the parameters of the Rodriguez-Iturbe, Cox and Eagleson models. The other half will be used for verification and intercomparison of the models.

This work is still ongoing with NSF support and four papers are in preparation:

- a. Eagleson, P.S., Q. Wang, N. Fennessey and I. Rodriguez-Iturbe, "Spatial Poisson Models of Stationary Storm Rainfall: An Application to Air Mass Thunderstorms" (in preparation for presentation at AGU Chapman Conference on Modeling of Rainfall Fields, Caracas Venezuela, March, 1986).
- b. Wang, Q., P.S. Eagleson, N. Fennessey and I. Rodriguez-Iturbe, "Spatial Poisson Models of Stationary Storm Rainfall: Numerical Simulation" (in preparation).
- c. Fennessey, N., P. S. Eagleson, Q. Wang and I. Rodriguez-Iturbe, "Spatial Poisson Models of Stationary Storm Rainfall: Reduction of Station Observations at Walnut Gulch" (in preparation).
- d. Wang, Q., N. Fennessey, P. S. Eagleson and I. Rodriguez-Iturbe, "Spatial Poisson Models of Stationary Storm Rainfall: Parameter Evaluation and Model Verification at Walnut Gulch" (in preparation).

C. Personnel

The work has been performed by Wang Qinliang, Visiting Engineer at MIT on leave from the Yangtze Valley Planning Office, Ministry of Water

Resources and Electric Power, People's Republic of China and by Neil Fennessey, Research Assistant in Civil Engineering at MIT under the supervision of Peter S. Eagleson, Edmund K. Turner Professor of Civil Engineering.